CLAIMS:

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A method for depositing ruthenium on a substrate, comprising:

exposing the substrate to a plasma which causes a high concentration of nucleation sites to be formed on the substrate, thus forming an exposed substrate; and

depositing ruthenium on the exposed substrate by atomic layer deposition.

2. The method of claim 1, wherein the substrate is selected from the group consisting of silicon dioxide, methyl silsesquioxane, hydrogen silsesquioxane, other low dielectric constant materials, and high dielectric constant oxide substrates.

3. The method of claim 1, wherein said plasma is an oxygen plasma.

4. The method of claim 3, wherein the oxygen plasma is generated by passing molecular oxygen through a plasma generation source to produce activated radicals to thereby generate a large number of nucleation sites on said substrate.

5. The method of claim 1, wherein said plasma is a nitrogen plasma.

6. The method of claim 5, wherein the nitrogen plasma is generated by passing molecular nitrogen through a plasma generation source to produce activated radicals to thereby generate a large number of nucleation sites on said substrate.

7. The method of claim 1, wherein said atomic layer deposition is performed by alternating steps of:

exposing the substrate to a ruthenium precursor for a first predetermined period of time; and

exposing the substrate to a plasma for a second predetermined time.

8. The method of claim 7, further comprising evacuating the ruthenium precursor and the plasma between successive steps.

9. The method of claim 8, wherein the evacuating is done for a period of substantially two seconds.

10. The method of claim 7, wherein the ruthenium precursor is selected from the group consisting of:
ruthenium cyclopentadienyl,
bis (ethylcyclopentadinyl)) ruthenium); and
((2,4-dimethylpentadienyl)ethylcyclopentadienyl) ruthenium).

11. The method of claim 7, wherein the ruthenium precursor is carried in a carrier gas.

12. The method of claim 11, wherein the carrier gas is argon.

13. The method of claim 7, wherein said first predetermined period of time is 4 seconds.

14. The method of claim 7, wherein said second predetermined period of time is 2 seconds.

15. The method of claim 1, wherein said exposing of said substrate to said plasma is performed for substantially 10 minutes or longer.

16. The method of claim 1, wherein said substrate is heated to a temperature of between 200 and 400 °C.

17. The method of claim 1, wherein said substrate is heated to a temperature of substantially 350 °C.

18. The method of claim 1, wherein said ruthenium is deposited directly on said substrate without use of a seed layer.

19. A method for depositing ruthenium on a substrate, comprising:

performing plasma enhanced atomic layer deposition of ruthenium on the substrate using a ruthenium

precursor and a plasma to form a thin film of ruthenium; and

depositing ruthenium on the thin film by thermal atomic layer deposition.

20. The method of claim 19, wherein said plasma is a hydrogen plasma.

21. The method of claim 19, wherein said atomic layer deposition is performed by alternating steps of:

exposing the substrate to a ruthenium precursor for a first predetermined period of time; and

exposing the substrate to a plasma for a second predetermined time.

22. The method of claim 21, further comprising evacuating the ruthenium precursor and the plasma between successive steps.

23. The method of claim 22, wherein the evacuating is done for a period of substantially two seconds.

24. The method of claim 21, wherein the ruthenium precursor is selected from the group consisting of:
ruthenium cyclopentadienyl,
bis (ethylcyclopentadinyl)) ruthenium); and
((2,4-dimethylpentadienyl)ethylcyclopentadienyl) ruthenium).

25. The method of claim 21, wherein the ruthenium precursor is carried in a carrier gas.

26. The method of claim 25, wherein the carrier gas is argon.

27. The method of claim 21, wherein said first predetermined period of time is 4 seconds.

28. The method of claim 21, wherein said second predetermined period of time is 2 seconds.

29. The method of claim 19, wherein said substrate is heated to a temperature of between 200 and 400 °C.

30. The method of claim 19, wherein said substrate is heated to a temperature of substantially 350 °C.

31. A ruthenium film formed by atomic layer deposition comprising less than three percent oxygen and less than 2 % carbon.

32. The ruthenium film of claim 31, configured as a gate of a CMOS device.

33. The ruthenium film of claim 31, deposited on a silicon dioxide substrate.

34. The ruthenium film of claim 31, deposited directly on a substrate without use of a seed layer.

35. The ruthenium film of claim 31, for serving as a plating layer for a copper interconnect.